IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

LINDQVIST et al. Atty. Ref.: JRL-1410-679

Serial No. 09/584,796 TC/A.U.: 2614

Filed: June 1, 2000 Examiner: Jamal, Alexander

For: A FREQUENCY DOMAIN ECHO CANCELLER

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January 2, 2008

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

RESPONSE TO NOTICE OF NON-COMPLIANT APPEAL BRIEF

In response to the Notice of Non-Compliant Appeal Brief dated December 17, 2007, Appellants hereby submit a new brief in which the summary of the claimed subject matter includes a mapping of each of the independent claims onto the specification by page and line number and to the drawings. Moreover, the argument section of the brief has been revised so that argument are placed under a separate heading for each ground of rejection on appeal. Substantive consideration of the Appeal Brief is respectfully requested.

Respectfully submitted,

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Before the Board of Patent Appeals and Interferences

BRIEF FOR APPELLANT
On Appeal From Final Rejection
From Group Art Unit 2643

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APPEAL BRIEF

I. REAL PARTY IN INTEREST

The real party in interest is the assignee, Telefonaktiebolaget L M Ericsson (publ), a Swedish corporation.

II. RELATED APPEALS AND INTERFERENCES

A pre-appeal was filed on November 9, 2005, which in accordance with a communication from the office on June 15, 2006, did not result in withdrawal of the final action. There are no other appeals related to this subject application. There are no interferences related to this subject application.

III. STATUS OF CLAIMS

Claims 1, 3-7, 9-28, and 30-44 are pending. Claims 1, 3-7, 9-17, 20-28, and 30-43 stand rejected under 35 U.S.C. §103 as being unpatentable over U.S. Patent 5,317,596 to Ho in view of U.S. Patent 6,597,745 to Dowling. Claims 18, 19, and 44 stand rejected under 35 U.S.C. §103 as being unpatentable over U.S. Patent 5,117,418 to Chaffee in view of Dowling. Claims 2, 8, and 29 are cancelled.

IV. STATUS OF AMENDMENTS

No amendment has been filed after the final action.

V. SUMMARY OF THE CLAIMED SUBJECT MATTER

The independent claims 1, 12, 18, 19, 20, and 30 in this case are directed to a frequency domain echo canceller, and independent claim 35 recites a method for reducing echo at a transceiver. Beneficial example applications of the frequency domain echo cancellers and method include multicarrier modulation methods, such as DMT (Discrete MultiTone), where digital subscriber lines are employed for high speed data transmission and OFDM (Orthogonal Frequency Division Multiplexing) based systems. Figure 1 shows a "near-end" DSL modem having a transmitter 12 and a receiver 14 connected to the subscriber line's twisted-pair 18 (telephone line) via a so-called hybrid circuit 16. The transmitted signal is

transmitted over a communications channel on the subscriber line to a "far-end" DSL modem (not shown), which has its own transmitter and receiver. Because the hybrid 16 cannot be exactly matched to the impedance of the subscriber line, the transmitted signal "leaks" back into the receiver through the hybrid creating an echo signal. An echo canceller in the "near end" station may be used to cancel the echo signal. The echo canceller first estimates the echo signal from the transmitted signal, and then subtracts the estimated echo signal from the received signal. In order to estimate the echo signal, the echo canceller must model the echo path channel. (See page 1, line 9-page 2, line 7).

A DMT signal that is filtered through a physical channel is subjected to inter-symbol-interference (ISI) because all practical physical channels have "memory," i.e., a non-zero impulse response. This impairment of the physical channel causes the transmitted DMT symbols to interfere with each other (ISI). Furthermore, the transitions between the DMT symbol cause transients in the received signal. These transients cause interference between the carriers in the same DMT symbol. This type of interference is known as inter-channel interference (ICI), where the "channel" refers to the DMT subchannel. ISI and ICI are two distinct phenomena that both cause data distortion. The echo signal received at the near-end station, like the data signal transmitted over the channel and received at the far-end station, is affected by ISI and ICI, because all practical

physical echo path channels have a long impulse response (memory). Thus, the echo from one carrier will leak into every other carrier within the same DMT symbol and the next transmitted DMT symbol. (See page 3, lines 8-21).

The frequency domain echo canceller recited in independent claim 20 takes into account interchannel interference when estimating an echo signal to be removed from a received signal. The frequency domain echo canceller recited in independent claim 30 takes into account intersymbol interference and interchannel interference when estimating an echo signal to be removed from a received signal. For example, see block 50 in Figure 3. Calculating the received echo signal completely in the frequency domain is particularly beneficial in a DMT type system because the transmitted data is already available in the frequency domain. Accordingly, the echo estimate is determined using a frequency domain model of an echo path channel that includes the effects of interference like ISI and ICI. (See page 4 and page 8, lines 22-page 9, line 2).

Seven non-limiting example embodiments of a frequency domain echo canceller are disclosed and claimed. In a first example embodiment to which independent claims 1 and 18 are directed, the frequency domain model of the echo path channel is determined using a first matrix of coefficients $\mathbf{H}_i$ and a second matrix of coefficients $\mathbf{W}_i$. The first matrix is combined with a current transmitted symbol $\mathbf{X}_i$, and the second matrix is combined with a previously transmitted

symbol $\mathbf{X}_{i-1}$. The sum of these two combinations is used to estimate the echo signal $\hat{\mathbf{Y}}_i$. The coefficients of the first matrix represent how an echo from a currently transmitted frequency domain signal affects a received signal. The coefficients of the second matrix represent how an echo from a previously transmitted domain symbol affects the received symbol. The coefficients of the first and second matrices are adjusted using a difference between the received signal and the estimated signal. (See page 9, line 3-page 14, line 20 and Figures 4 and 5).

In a second example embodiment, the current transmitted symbol and the previously transmitted symbol are partitioned into real and imaginary parts before being combined with matrices as described in the first example embodiment. This operation reduces the computational complexity by a factor of two compared to the first example embodiment. (See page 14, line 21-page 17, line 9).

In a third example embodiment to which independent claims 12 and 19 are directed, the currently transmitted symbol is combined with a first column vector $\mathbf{V}_i$. The previously transmitted symbol is multiplied with a complex exponential term, $e^{j2\pi Lk/N}$, in order to compensate for the cyclic prefix, and then subtracted from the current transmitted symbol. The resulting signal is combined with a matrix $\mathbf{Z}_i$. The vector and matrix combinations are summed and used to estimate the echo signal to be removed from the received symbol. See equations 40 and 41.

This third example embodiment reduces the computational complexity approximately by a factor of two compared to the first example embodiment. (See page 17, line 10-page 18, line 17 and Figure 6). Independent method claim 35 is directed to both the first and third embodiments.

In a fourth example embodiment, the operations described in the second and third example embodiments are combined resulting in a reduction of computational complexity approximately by a factor of four compared to the first example embodiment. (See page 18, line 18-page 19, line 6).

In a fifth example embodiment, when the transmitter of a transceiver has a lower sampling rate than its receiver, the received echo signal is interpolated at the receiver. The interpolation may also be combined with the operations described in the second example embodiment to reduce the computational complexity by a factor of four compared to the first example embodiment. (See page 19, line7-page 20, line 10).

In a sixth example embodiment, when the transmitter has a higher rate than the receiver, the echo signal is decimated at the receiver. The decimation may also be combined with the operations described in the second example embodiment to reduce the computational complexity by a factor of four compared to the first example embodiment. (See page 20, line 11-page 21 line 12).

In a seventh example embodiment, when the transmitted symbols are not aligned in time with the received symbols or frames, an asynchronous echo canceller may be used. The asynchronous echo canceller may be combined with previously-described example embodiments. (See page 22, lines 3-21).

In a DMT type modem, because all of the data is already available in the frequency domain, there is no need to do any additional Fourier transform or inverse Fourier transform operations, except for the asynchronous echo canceller embodiment which requires one extra IDFT. Moreover, some of the coefficients in the matrices may be very small and ignored, further reducing the computational complexity and memory required.

The following tables map each independent claim onto example, non-limiting features in the specification and figures as required by the rules.[1]

1. An echo canceller for use in a transceiver, comprising:	See echo canceller 50 in Figure 3 in a transceiver 20 including transmitter 22 and receiver 26.
first electronic circuitry configured to estimate in the frequency domain an echo signal, and	The echo canceller 50 includes electronic circuitry. See the function block representation in the example

[1] This mapping in no way limits the claim scope and is not intended to be used in construing the meaning of claim terms.

	of Figure 4 blocks 60, 62, and 64, and steps 72, 74, and 76 in Figure 5. See the example description on page 4, lines 19-26, page 8, line 22-page 9, line 2, and page 12, line 19-page 13, line 8.
second electronic circuitry configured to remove in the frequency domain the estimated echo signal in the frequency domain from a received signal in the frequency domain,	See the subtraction in Figure 4 and the last two steps of Figure 5. See page 9, line 3-page 14, line 20 and especially page 13, lines 9-12.
wherein the first electronic circuitry is further configured to estimate the echo signals in the frequency domain using a combination of (i) a product of a first matrix of coefficients in the frequency domain and a transmitted symbol and (ii) a product of a second matrix of coefficients in the frequency domain and a previously-transmitted symbol.	See the function block representation in the example of Figure 4 blocks 60, 62, and 64, and steps 72, 74, and 76 in Figure 5. See the example description on page 4, lines 19-26, page 8, line 22-page 9, line 2, and page 12, line 19-page 13, line 8.

12. The echo canceller for use in a transceiver, comprising:	See the echo canceller 50 in Figure 3 in a transceiver 20 including transmitter 22 and receiver 26.
first electronic circuitry configured to estimate in the frequency domain an echo signal, and	The echo canceller 50 includes electronic circuitry. See the function block representation in the example of Figure 6 blocks 60, 90, 92, and 94, and steps 102, 104, and 106 in Figure 7. See the example description on page 17, line 10-page 18, line 17.
second electronic circuitry configured to remove in the frequency domain the estimated echo signal in the frequency domain from a received signal in the frequency domain,	See the subtraction in Figure 6 and the last two steps of Figure 7. See page 18, lines 15-17.
wherein the first electronic circuitry is further configured to estimate the echo signals in the frequency domain using a	See the function block representation in the example of Figure 6 blocks 60, 90, 92, and 94,

combination of a product of (i) a vector of coefficients in the frequency domain and a transmitted symbol and (ii) a product of a matrix of coefficients in the frequency domain and a compensated, previously-transmitted symbol.	and steps 102, 104, and 106 in Figure 7. See the example description on page 17, line 10-page 18, line 17.

18. An echo canceller for use in an asynchronous transceiver configured to cancel an echo signal, comprising:	See the echo canceller in Figure 9 in an asynchronous transceiver.
a first matrix of coefficients;	See matrix H_i.
a second matrix of coefficients; and	See matrix W_i.
electronic circuitry configured to use a combination of (i) a product of the first matrix and a currently-transmitted symbol and (ii) a product of the second matrix and a previously-transmitted symbol to estimate an echo signal in the frequency domain, to transform the estimate of the echo signal into the time domain, and to remove the	The echo canceller includes MBAEC and related electronic circuitry as shown in the function block representation in the example of Figure 9. The description at page 22, lines 3-21 explains that this asynchronous transceiver may be applied to any of the previously

transformed estimate from a received signal in the time domain.	described embodiments.

19. An echo canceller for use in an asynchronous transceiver configured to cancel an echo signal, comprising:	See the echo canceller in Figure 9 in an asynchronous transceiver..
a vector of coefficients in the frequency domain;	See vector V_i.
a matrix of coefficients in the frequency domain,	See matrix Z_i.
electronic circuitry configured to use a combination of (i) a product of the vector and a currently-transmitted symbol and (ii) a product of the matrix and a compensated, previously-transmitted symbol to estimate an echo signal in the frequency domain, to transform the estimated echo signal into the time domain, and to remove from a received signal in the time domain.	The echo canceller includes MBAEC and related electronic circuitry as shown in the function block representation in the example of Figure 9. The description at page 22, lines 3-21 explains that this asynchronous transceiver may be applied to any of the previously described embodiments.

20. An echo canceller for use in a transceiver canceling an echo from a received signal in the frequency domain including circuitry configured to determine an estimate of the echo in the received signal using a frequency domain model of an echo path channel that takes into account effects of inter-carrier interference and to subtract the echo estimate from the received signal.	See echo canceller 50 in Figure 3 in a transceiver 20 including transmitter 22 and receiver 26. See the function block representation in the example of Figure 4 blocks 60, 62, and 64, and steps 72, 74, and 76 in Figure 5. See the example description on page 4, lines 12-18, page 8, line 22-page 9, line 2, and page 12, line 9-page 13, line 8. See the example echo subtraction in Figure 4 and the last two steps of Figure 5. See page 9, line 3-page 14, line 20 and especially page 13, lines 9-12.

30. A frequency domain echo canceller for use in a transceiver canceling an echo from a received signal in the frequency domain including circuitry configured to	See echo canceller 50 in Figure 3 in a transceiver 20 including transmitter 22 and receiver 26. See the function block representation in

determine an estimate of the echo in the received signal using a frequency domain model of an echo path channel that includes effects of intersymbol interference and inter-carrier interference and to subtract the echo estimate from the received signal to provide a difference.	the example of Figure 4 blocks 60, 62, and 64, and steps 72, 74, and 76 in Figure 5. See the example description on page 4, lines 12-18, page 8, line 22-page 9, line 2, and page 12, line 9-page 13, line 8. See the example echo subtraction in Figure 4 and the last two steps of Figure 5. See page 9, line 3-page 14, line 20 and especially page 13, lines 9-12.

35. A method for reducing an echo at a transceiver comprising:	See echo canceller 50 in Figure 3 in a transceiver 20 including transmitter 22 and receiver 26.
(a) combining in the frequency domain a currently-transmitted symbol with a first vector or matrix of coefficients in the frequency domain resulting in a first combination;	For the first vector, see the function block representation in the example of Figure 6 blocks 60, 90, 92, and 94, and steps 102, 104, and 106 in Figure 7. See the example

	description on page 17, line 10-page 18, line 17. For the first matrix, see the function block representation in the example of Figure 4 blocks 60, 62, and 64, and steps 72, 74, and 76 in Figure 5. See the example description on page 4, lines 19-26, page 8, line 22-page 9, line 2, and page 12, line 19-page 13, line 8.
(b) combining in the frequency domain a previously-transmitted symbol with a second matrix of coefficients in the frequency domain resulting in a second combination;	For the first vector, see the function block representation in the example of Figure 6 blocks 60, 90, 92, and 94, and steps 102, 104, and 106 in Figure 7. See the example description on page 17, line 10-page 18, line 17. For the first matrix, see the function block representation in the example of Figure 4 blocks 60, 62, and 64, and

	steps 72, 74, and 76 in Figure 5. See the example description on page 4, lines 19-26, page 8, line 22-page 9, line 2, and page 12, line 19-page 13, line 8.
(c) combining the first and second combinations in the frequency domain to estimate the echo in the frequency domain; and	For the first vector, see the function block representation in the example of Figure 6 blocks 60, 90, 92, and 94, and steps 102, 104, and 106 in Figure 7. See the example description on page 17, line 10-page 18, line 17. For the first matrix, see the function block representation in the example of Figure 4 blocks 60, 62, and 64, and steps 72, 74, and 76 in Figure 5. See the example description on page 4, lines 19-26, page 8, line 22-page 9, line 2, and page 12, line 19-page 13, line 8.

(d) using the estimated echo to reduce the echo in a signal received at the transceiver.	For the vector, see the subtraction in Figure 6 and the last two steps of Figure 7. See page 18, lines 15-17. For the first matrix, see the subtraction in Figure 4 and the last two steps of Figure 5. See page 9, line 3-page 14, line 20 and especially page 13, lines 9-12.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The two grounds of rejection to be reviewed on appeal are the obviousness rejections under 35 U.S.C. §103 based on (1) the combination of Ho in view of Dowling, and (2) the combination of Chaffee in view of Dowling.

VII. ARGUMENT

A. The Rejection of Claims 1, 12, 20, 30, and 35 Under 35 U.S.C. §103 Based On Ho and Dowling Is Improper

Independent claims 1, 12, 20, 30, and 35 all recite estimating and removing echo *in the frequency domain* using a specific approach. The Examiner admits that Ho does not teach estimating the echo signals in the frequency domain using a combination of (i) a product of a first matrix (specifically a vector in claim 12) of coefficients in the frequency domain and a transmitted symbol and (ii) a product of a second matrix of coefficients in the frequency domain and a previously-transmitted symbol.

Ho relies primarily on echo cancellation in the *time* domain. See lines 10-13 of col. 6: "After the adder **52** *subtracts the time-domain portion of the echo*, e(n), the output is converted by a serial-to-parallel (S/P) converter **54** into a block of N real-valued time-domain samples." Then a residual echo is converted from the time to the frequency domain so that a residual echo E(f) is removed. Hence, *the main echo is removed in the time-domain*, and then the result is corrected in frequency-domain. The reason Ho takes this approach is that Ho does not (and can not) remove the echo due to a previous symbol in the frequency domain.

The Examiner relies on Dowling to remedy the deficiencies in Ho. That reliance is misplaced.

Dowling describes a "pre-coder" which is a pre-equalizer—not an echo canceller. Dowling *precodes* a signal *before* the signal is transmitted in order to compensate for transmission channel distortion (not echo) that would otherwise distort the signal received at the intended receiver, i.e., the far-end station. The hope is that this precoded signal will be received without the far-end station having to equalize the signal. In other words, Dowling tries to compensate for the channel distortion before transmission over the channel so that the transmitted signal is received at the other end of the transmission channel more or less undistorted (at least in theory). So Dowling is concerned about the signal received at the far-end station. Compensating for the distortion caused by a transmission channel is an entirely different problem as compared to canceling an echo.

In contrast, the claimed echo cancellation is at the near-end station, and the echo that the near-end station must deal with is reflected back through an echo path to the near-end station. These basic facts would be well understood by those skilled in echo cancellation.[2] While Dowling effectively pre-equalizes (precodes) the transmitted signal for the transmission channel in order to simplify signal processing in the far-end station, the instant claims remove echo in the near-end

station caused by the near-end transmitted signal. These are two very different operations responding to two different problems.

1. Compensating For Channel Distortion Does Not Compensate For Echo

Dowling's precoder does not estimate and remove an echo signal from a received signal—let alone do this in the frequency domain. Rather, Dowling estimates and "removes" the expected transmission channel distortion from the transmitted signal so that distortion introduced by the transmission channel will be minimized at the far-end station receiver. Dowling's channel distortion estimate ***does not include echo cancellation***. Echo is caused by transmission line impedance mismatches, which is different from the channel transfer function. Echo is experienced at the near-end station transmitter, and not at the far-end station receiver, which is the intended beneficiary of Dowling's precoding. Why would Dowling model/estimate an echo that is not part of the channel distortion of the signal received at the far-end station receiver? Echo is a problem for the near-end station to deal with and not the far-end station.

The Examiner relies on col. 22, lines 1-3, where Dowling states that "communication systems often involve other elements such as echo cancellers

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[2] For a brief background regarding echo cancellation, please see pages 1 and 2 of the instant specification and Figure 1.

which may be advantageously merged with the precoder." But here *Dowling admits that his precoder/pre-equalizer does not perform echo cancellation.* If echo is to be canceled, Dowling explicitly states that an echo canceller is needed because his precoder does not cancel echo. Thus, the Examiner's premise that Dowling's precoder some how removes the echo from the transmitted signal cannot stand.

2. The Ho/Dowling Combination Falls Short

Even if Dowling's precoder were "merged" with Ho's echo canceller, one would not arrive at the claimed echo cancellation. Dowling's precoder, by Dowling's own admission, does not perform echo cancellation. Hence, in the Examiner's proposed combination, it is just Ho's echo canceller doing the echo cancellation, which the Examiner rightly admits is <u>not</u> the claimed echo cancellation. So the proposed combination fails.

To cancel echo, (which is not transmitted over the transmission channel), a model of the echo is needed; however, a model of the transmission channel is not. On the other hand, Dowling's precoding modifies the transmitted signal using an inversion of the *transmission channel* transfer function (not an echo channel transfer function). The hoped for result is the receiver gets a signal that is more or less unaffected by the transmission channel transfer function. But only knowledge of the transmission channel is needed and not the echo experienced at the near-end

station. And in the merged combination of Ho and Dowling, where Dowling's precoder is used along with a separate and distinct echo canceller, the echo is removed from the transmitted signal in a conventional way rather than as claimed.

3. The Ho/Dowling Combination Would Not Have Been Made By A Person Of Ordinary Skill In The Art

Notwithstanding the significant deficiencies already noted, assume for the sake of argument that there was some provision by Dowling to precode the signal to be transmitted for echo cancellation—which Dowling plainly does not do—along with precoding for the transmission channel. The echo would be modeled and then inverted (call this X) just like the transmission channel is modeled and inverted (call this Y). But the consequence is that the inverted echo model X negatively affects the inverted channel model Y resulting in distorting the received signal even more at the far-end station receiver. For this reason alone, a person skilled in this art would not make this modification.

Moreover, further distorting of the signal at the far-end receiver and the need for more sophisticated equalization at the far-end receiver are the very things Dowling is trying to avoid. Dowling's title is "Reduced Complexity Multicarrier Precoder," and column 2, lines 41-42 state: "The foregoing indicates a recognized but unmet need for a reduced complexity DMT-THP [a DMT-THP is defined in column 1, lines 23-24 as "a transmitter-based precoder structure"]." Thus, the

Examiner requires in the combinations upon which the final rejections are based a modification that renders Dowling inoperable for Dowling's consistently articulated and intended purpose. This thwarting of Dowling's primary purpose is a clear indicator of an inappropriate obviousness rejection. *In re Gordon*, 733 F.2d 900, 902 (Fed. Cir. 1984).

Consider an alternative combination where Dowling's precoded signal is directly applied to the input of Ho's echo canceller. In this case, that applied signal is still only compensated for transmission channel ISI and ICI. The echo ISI and ICI would not be compensated for, but instead would be additionally distorted. Accordingly, Ho's echo canceller cannot be combined with Dowling's precoder in the manner proposed by the Examiner to result in the claimed echo canceller. Such a proposed combination certainly does not result in estimating a echo signal in the frequency domain using the claimed combination of first and second matrices with a transmitted symbol and a previously-transmitted symbol.

These significant obstacles and inconsistencies with trying to combine Dowling with Ho demonstrate that there is no reason to combine them. A proper motivation to combine requires an appreciation of the desirability of making the combination. It is not measured by the feasibility of making the combination. See *Winner Int'l Royalty Corp. v. Wang*, 202 F.3d 1340, 1349 (Fed. Cir. 2000). In this case, the combination has been shown to be both undesirable and infeasible.

Still further, the Examiner must show reasons that the skilled artisan, confronted with *the same problems* as the inventor and *no knowledge of the claimed invention*, would select the elements from the cited prior art references for the combination in the manner claimed. *In re Rouffet*, 149 F.3d 1350, 1357 (Fed. Cir. 1998). Neither Ho nor Dowling reduces the negative affects of ICI and ISI in echo cancellation using a frequency domain echo canceller.

4. Ho And Dowling Do Not Compensate for Echo ICI or ISI

The features recited in claims 20 and 30 are not taught in the combination of Ho and Dowling. The frequency domain echo canceler in claim 30 "estimate[s] the echo in the received signal using *a frequency domain model of an echo path* channel that *includes effects of intersymbol interference and inter-carrier interference and to subtract the echo estimate from the received signal* to provide a difference." See also claims 20 and 21. Neither Ho nor Dowling teaches an echo canceller that takes into account effects of **echo** inter-carrier interference (ICI) and inter-symbol interference (ISI) in a frequency domain model of an echo estimate so that it can be subtracted out from the received echo at the near-end station.

The Examiner assumes that ICI is a form of either ISI or noise. To the contrary, as explained in the background of this application, ICI is not the same as

ISI. Nor is ICI simply "noise." The two articles previously-provided to the Examiner and attached in the Evidence Appendix confirm this.

Another fundamental point ignored by the Examiner is that the ISI and ICI in the transmitted signal sent over the transmission channel are not the same as the ISI and ICI in the echo. None of the applied references model or compensate for the **echo** ISI and **echo** ICI.

Still further, the rejection of claims 20 and 30 is improper because the combination of Ho and Dowling cannot be properly made for the myriad reasons already explained.

B. The Rejection of Claims 18, 19, and 44 Under 35 U.S.C. §103 Based on Chaffee and Dowling Is Improper

Independent claims 18 and 19 all recite estimating echo in the frequency domain using a specific approach.[3] The Examiner admits that Chaffee does not "disclose that the echo signals are estimated with a combination of both a product of a first matrix and transmitted symbol and a product of a second matrix and a previously transmitted symbol." (For claim 19, the claimed vector rather than the first matrix is multiplied by the transmitted symbol.) The Examiner relies on Dowling to remedy the deficiencies in Chaffee. That reliance is misplaced.

[3] The rejection of claim 44 is assumed to be based on Ho, Chaffee, and Dowling since claim 44 depends from claim 35 which is rejected based on Ho and Dowling.

Dowling describes a "pre-coder" which is a pre-equalizer—not an echo canceller. Dowling *precodes* a signal *before* the signal is transmitted in order to compensate for transmission channel distortion (not echo) that would otherwise distort the signal received at the intended receiver, i.e., the far-end station. The hope is that this precoded signal will be received without the far-end station having to equalize the signal. In other words, Dowling tries to compensate for the channel distortion before transmission over the channel so that the transmitted signal is received at the other end of the transmission channel more or less undistorted (at least in theory). So Dowling is concerned about the signal received at the far-end station. Compensating for the distortion caused by a transmission channel is an entirely different problem as compared to canceling an echo.

In contrast, the claimed echo cancellation is at the near-end station, and the echo that the near-end station must deal with is reflected back through an echo path to the near-end station. These basic facts would be well understood by those skilled in echo cancellation. While Dowling effectively pre-equalizes (precodes) the transmitted signal for the transmission channel in order to simplify signal processing in the far-end station, the instant claims remove echo in the near-end station caused by the near-end transmitted signal. These are two very different operations responding to two different problems.

1. Compensating For Channel Distortion Does Not Compensate For Echo

Dowling's precoder does not estimate and remove an echo signal from a received signal—let alone do this in the frequency domain. Rather, Dowling estimates and "removes" the expected transmission channel distortion from the transmitted signal so that distortion introduced by the transmission channel will be minimized at the far-end station receiver. Dowling's channel distortion estimate ***does not include echo cancellation***. Echo is caused by transmission line impedance mismatches, which is different from the channel transfer function. Echo is experienced at the near-end station transmitter, and not at the far-end station receiver, which is the intended beneficiary of Dowling's precoding. Why would Dowling model/estimate an echo that is not part of the channel distortion of the signal received at the far-end station receiver? Echo is a problem for the near-end station to deal with and not the far-end station.

The Examiner relies on col. 22, lines 1-3, where Dowling states that "communication systems often involve other elements such as echo cancellers which may be advantageously merged with the precoder." But here *Dowling admits that his precoder/pre-equalizer does not perform echo cancellation*. If echo is to be canceled, Dowling explicitly states that an echo canceller is needed because his precoder does not cancel echo. Thus, the Examiner's premise that

Dowling's precoder some how removes the echo from the transmitted signal cannot stand.

2. The Chaffee/Dowling Combination Falls Short

Even if Dowling's precoder were "merged" with Chaffee's echo canceller, one would not arrive at the claimed echo cancellation. Dowling's precoder, by Dowling's own admission, does not perform echo cancellation. Hence, in the Examiner's proposed combination, it is just Chaffee's echo canceller doing the echo cancellation, which the Examiner rightly admits is not the claimed echo cancellation. So the proposed combination fails.

To cancel echo, (which is not transmitted over the transmission channel), a model of the echo is needed; however, a model of the transmission channel is not. On the other hand, Dowling's precoding modifies the transmitted signal using an inversion of the *transmission channel* transfer function (not an echo channel transfer function). The hoped for result is the receiver gets a signal that is more or less unaffected by the transmission channel transfer function. But only knowledge of the transmission channel is needed and not the echo experienced at the near-end station. And in the merged combination of Chaffee and Dowling, where Dowling's precoder is used along with a separate and distinct echo canceller, the echo is removed from the transmitted signal in a conventional way rather than as claimed.

3. The Chaffee/Dowling Combination Would Not Have Been Made By A Person Of Ordinary Skill In The Art

Notwithstanding the significant deficiencies already noted, assume for the sake of argument that there was some provision by Dowling to precode the signal to be transmitted for echo cancellation—which Dowling plainly does not do—along with precoding for the transmission channel. The echo would be modeled and then inverted (call this X) just like the transmission channel is modeled and inverted (call this Y). But the consequence is that the inverted echo model X negatively affects the inverted channel model Y resulting in distorting the received signal even more at the far-end station receiver. For this reason alone, a person skilled in this art would not make this modification.

Moreover, further distorting of the signal at the far-end receiver and the need for more sophisticated equalization at the far-end receiver are the very things Dowling is trying to avoid. Dowling's title is "Reduced Complexity Multicarrier Precoder," and column 2, lines 41-42 state: "The foregoing indicates a recognized but unmet need for a reduced complexity DMT-THP [a DMT-THP is defined in column 1, lines 23-24 as "a transmitter-based precoder structure"]." Thus, the Examiner requires in the combinations upon which the final rejections are based a modification that renders Dowling inoperable for Dowling's consistently articulated and intended purpose. This thwarting of Dowling's primary purpose is

a clear indicator of an inappropriate obviousness rejection. *In re Gordon*, 733 F.2d 900, 902 (Fed. Cir. 1984).

Consider an alternative combination where Dowling's precoded signal is directly applied to the input of Chaffee's echo canceller. In this case, that applied signal is still only compensated for transmission channel ISI and ICI. The echo ISI and ICI would not be compensated for, but instead would be additionally distorted. Accordingly, Chaffee's echo canceller cannot be combined with Dowling's precoder in the manner proposed by the Examiner to result in the claimed echo canceller. Such a proposed combination certainly does not result in estimating a echo signal in the frequency domain using the claimed combination of first and second matrices with a transmitted symbol and a previously-transmitted symbol.

These significant obstacles and inconsistencies with trying to combine Dowling with Chaffee demonstrate that there is no reason to combine them. A proper motivation to combine requires an appreciation of the desirability of making the combination. It is not measured by the feasibility of making the combination. See *Winner Int'l Royalty Corp. v. Wang*, 202 F.3d 1340, 1349 (Fed. Cir. 2000). In this case, the combination has been shown to be both undesirable and infeasible.

Still further, the Examiner must show reasons that the skilled artisan, confronted with *the same problems* as the inventor and *no knowledge of the claimed invention*, would select the elements from the cited prior art references for the combination in the manner claimed. *In re Rouffet*, 149 F.3d 1350, 1357 (Fed. Cir. 1998). Neither Chaffee nor Dowling reduces the negative affects of ICI and ISI in echo cancellation using a frequency domain echo canceller.

VII. CONCLUSION

Multiple features of the independent claims are not disclosed or suggested by the combination of Ho and Dowling or Chaffee and Dowling. Nor is there proper motivation to combine their teachings as the Examiner proposes. Each missing claim feature and the lack of motivation for each combination is an independent ground for reversal. The Board should reverse the outstanding rejections.

Respectfully submitted,

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JRL/maa
Enclosures

IX. CLAIMS APPENDIX

1. An echo canceller for use in a transceiver, comprising:

first electronic circuitry configured to estimate in the frequency domain an echo signal, and

second electronic circuitry configured to remove in the frequency domain the estimated echo signal in the frequency domain from a received signal in the frequency domain,

wherein the first electronic circuitry is further configured to estimate the echo signals in the frequency domain using a combination of (i) a product of a first matrix of coefficients in the frequency domain and a transmitted symbol and (ii) a product of a second matrix of coefficients in the frequency domain and a previously-transmitted symbol.

3. The echo canceller in claim 1, wherein transmitted signals corresponding to the transmitted symbol and the previously-transmitted symbol are real-valued, and wherein the transmitted symbol and the previously-transmitted symbol are divided into real and imaginary parts before being combined with the respective matrix to reduce computational complexity.

4. The echo canceller in claim 1, wherein the coefficients of the first matrix represent how an echo from a currently transmitted frequency domain signal affects a received signal.

5. The echo canceller in claim 4, wherein the coefficients of the second matrix represent how an echo from a previously transmitted frequency domain signal affects the received signal.

6. The echo canceller in claim 1, wherein the first electronic circuitry is further configured to adapt the coefficients of the first matrix and the second matrix using a difference between the received signal and the estimated echo signal.

7. The echo canceller in claim 6, wherein the first electronic circuitry is further configured to adapt the coefficients using a least mean squares algorithm.

9. The echo canceller in claim 1, wherein the transceiver is a discrete multitone (DMT) transceiver.

10. The echo canceller in claim 1, wherein the first and second matrices are N x N matrices, where N is a number of symbol samples.

11. The echo canceller in claim 1, wherein a vector corresponding to a transmitted frequency domain symbol, a vector corresponding to a received frequency domain signal, and a vector corresponding to an estimate of the echo symbol are all Hermitian symmetric.

12. The echo canceller for use in a transceiver, comprising:

first electronic circuitry configured to estimate in the frequency domain an echo signal, and

second electronic circuitry configured to remove in the frequency domain the estimated echo signal in the frequency domain from a received signal in the frequency domain,

wherein the first electronic circuitry is further configured to estimate the echo signals in the frequency domain using a combination of a product of (i) a vector of coefficients in the frequency domain and a transmitted symbol and (ii) a product of a matrix of coefficients in the frequency domain and a compensated, previously-transmitted symbol.

13. The echo canceller in claim 12, wherein the first electronic circuitry is further configured to divide the transmitted symbol and the previously-transmitted symbol into real and imaginary parts before combining them respectively with the vector and the matrix to reduce computational complexity.

14. The echo canceller in claim 12, wherein a compensation factor used to compensate the previously-transmitted signal is a complex exponential term.

15. The echo canceller in claim 14, wherein the transceiver is a discrete multitone (DMT) transceiver and the compensation factor compensates for a cyclic prefix associated with the previously-transmitted signal.

16. The echo canceller in claim 1, wherein when a transmitter of the transceiver has a lower sampling rate than a receiver of the transceiver, the echo signal is interpolated at the receiver.

17. The echo canceller in claim 1, wherein when a transmitter of the transceiver has a higher sampling rate than a receiver of the transceiver, the echo signal is decimated at the receiver.

18. An echo canceller for use in an asynchronous transceiver configured to cancel an echo signal, comprising:

a first matrix of coefficients;

a second matrix of coefficients; and

electronic circuitry configured to use a combination of (i) a product of the first matrix and a currently-transmitted symbol and (ii) a product of the second matrix and a previously-transmitted symbol to estimate an echo signal in the frequency domain, to transform the estimate of the echo signal into the time domain, and to remove the transformed estimate from a received signal in the time domain.

19. An echo canceller for use in an asynchronous transceiver configured to cancel an echo signal, comprising:

a vector of coefficients in the frequency domain;

a matrix of coefficients in the frequency domain,

electronic circuitry configured to use a combination of (i) a product of the vector and a currently-transmitted symbol and (ii) a product of the matrix and a compensated, previously-transmitted symbol to estimate an echo signal in the frequency domain, to transform the estimated echo signal into the time domain, and to remove the transformed estimate from a received signal in the time domain.

20. An echo canceller for use in a transceiver canceling an echo from a received signal in the frequency domain including circuitry configured to determine an estimate of the echo in the received signal using a frequency domain model of an echo path channel that takes into account effects of inter-carrier interference and to subtract the echo estimate from the received signal.

21. The echo canceller in claim 20, wherein the echo canceller is used in a discrete multitone (DMT) type transceiver and the frequency domain model takes into account intersymbol interference .

22. The echo canceller in claim 20, wherein the frequency domain model includes a first set of values that models how an echo from a currently transmitted frequency domain symbol distorts the received signal and a second set of values that models how an echo from a previously transmitted frequency domain symbol distorts the received signal.

23. The echo canceller in claim 22, wherein the first set of values is a first complex matrix and the second set of values is a second complex matrix.

24. The echo canceller in claim 22, wherein the first set of values is a column vector and the second set of values is a matrix.

25. The echo canceller in claim 24, wherein the matrix is combined with a difference between the currently transmitted symbol and a product of the previously transmitted symbol and a compensating factor.

26. The echo canceller in claim 22, wherein the transmitted symbol and the previously transmitted symbol are divided into real and imaginary parts before being combined with the first and second sets of values, respectively.

27. The echo canceller in claim 20, wherein when a transmitter of the transceiver has a lower sampling rate than a receiver of the transceiver, the echo signal is interpolated at the receiver.

28. The echo canceller in claim 20, wherein when a transmitter of the transceiver has a higher sampling rate than a receiver of the transceiver, the echo signal is decimated at the receiver.

30. A frequency domain echo canceller for use in a transceiver canceling an echo from a received signal in the frequency domain including circuitry configured to determine an estimate of the echo in the received signal using a frequency domain model of an echo path channel that includes effects of intersymbol interference and inter-carrier interference and to subtract the echo estimate from the received signal to provide a difference.

31. The echo canceller in claim 30, wherein the frequency domain model includes a first set of values that models completely in the frequency domain how an echo from a currently transmitted frequency domain symbol distorts the received signal and a second set of values that models completely in the frequency domain how an echo from a previously transmitted frequency domain symbol distorts the received signal.

32. The echo canceller in claim 31, wherein transmitted signals corresponding to the currently and previously transmitted frequency domain symbols are real-valued.

33. The echo canceller in claim 32, wherein the currently transmitted symbol, the previously transmitted symbol, the received signal, and the difference are vectors having Hermitian symmetry.

34. The echo canceller in claim 31, wherein the difference is used to adjust the first and second set of values.

35. A method for reducing an echo at a transceiver comprising:

(a) combining in the frequency domain a currently-transmitted symbol with a first vector or matrix of coefficients in the frequency domain resulting in a first combination;

(b) combining in the frequency domain a previously-transmitted symbol with a second matrix of coefficients in the frequency domain resulting in a second combination;

(c) combining the first and second combinations in the frequency domain to estimate the echo in the frequency domain; and

(d) using the estimated echo to reduce the echo in a signal received at the transceiver.

36. The method in claim 35, further comprising:

determining a difference between the received signal and the estimated echo, and adjusting the first and second set of values using the difference.

37. The method in claim 35, wherein the first vector or matrix corresponds to a first matrix of coefficients .

38. The method in claim 35, wherein the first vector or matrix corresponds to a column vector of coefficients .

39. The method in claim 38, wherein the combining step (b) includes:

multiplying the previously transmitted symbol by a compensation factor to produce a product;

subtracting the product from the currently transmitted symbol; and

combining a result of the subtracting with the matrix.

40. The method in claim 35, wherein when a transmitter of the transceiver has a lower sampling rate than a receiver of the transceiver, the method further comprising:

interpolating the echo signal.

41. The method in claim 35, wherein when a transmitter of the transceiver has a higher sampling rate than a receiver of the transceiver, the method further comprising:

decimating the echo signal.

42. The method in claim 35, wherein a vector corresponding to a transmitted frequency domain symbol, a vector corresponding to a received frequency domain signal, a vector corresponding to an estimate of the echo symbol are Hermitian symmetric.

43. The method in claim 35, further comprising:

dividing the currently transmitted symbol and the previously-transmitted symbol into real and imaginary parts before the combining steps (a) and (b), respectively, to reduce computational complexity.

44. The method according to claim 35, wherein the transceiver is an asynchronous transceiver, the method further comprising:

transforming the estimated echo into the time domain, and

removing in the time domain, the estimated echo signal from the received signal on a sample-by-sample basis.

X. EVIDENCE APPENDIX

Two articles are attached that were submitted to the Examiner on June 15, 2005 and are referred to in the argument section above: "A Novel Intercarrier Interference Cancellation Approach in OFDM based on BSS," by Liu et al and "Residual Frequency Offset Correction for Coherently Modulated OFDM Systems in Wireless Communication," by Abhayawardhana et al.

XI. RELATED PROCEEDINGS APPENDIX

There is no related proceedings appendix.